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Re-design of stormwater sewer network by introducing an end of pipe underground stormwater treatment system

Reconception d'un réseau séparatif pluvial par l'introduction d'un système de traitement souterrain des eaux en aval du tuyau

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RÉSUMÉ

Dans cette étude, l'efficacité du traitement d'une voûte de sédimentation souterraine compacte (EcoVault) contenant une étape de sédimentation et de filtration est étudiée. Elle a été installée comme installation en bout de tuyau dans un réseau d'assainissement des eaux pluviales existant pour traiter les eaux de ruissellement d'une zone urbaine. Six événements pluvieux ont été analysés, de mai à novembre 2022. L'accent a été mis sur le traitement du Cu et du Zn totaux et dissous, ainsi que sur les matières en suspension totales. Des échantillons proportionnels au temps ont été prélevés à l'entrée, après l'étape de sédimentation et à la sortie. L'installation de traitement a été capable de réduire la concentration totale de solides en suspension en moyenne de 50%. On a constaté un colmatage notable des filtres de l'installation. Le niveau de traitement de la concentration en métaux était plus faible, le Cu total a été réduit de 25% et le Zn total de 15% seulement. Les filtres n'ont pas éliminé les métaux dissous ; en fait, on a constaté une augmentation du Cu et du Zn dissous de 33 % et 44 %, respectivement, dans les échantillons d'effluents.

ABSTRACT

In this study the treatment efficiency of a compact underground sedimentation vault (EcoVault) containing a sedimentation and filtration step is investigated. It has been installed as end-of-pipe facility into an existing stormwater sewage network to treat runoff from an urban area. Six rain events were analysed, from May to November 2022. Emphasis was put on the treatment of total and dissolved Cu and Zn, as well as the total suspended solids. Time proportional samples were taken from the inlet, after the sedimentation step and from the outlet. The treatment facility was able to reduce total suspended solids concentration on average by 50%. There was a noticeable clogging of the filters in the facility. The level of metal concentration treatment was lower, total Cu was reduced by 25% and total Zn by 15% only. The filters did not remove dissolved metals; in fact there was an increase of dissolved Cu and Zn by 33% and 44%, respectively, in the effluent samples.

KEYWORDS

Area-efficient treatment, Field study, Retrofitting stormwater infrastructure, Stormwater treatment

1 BACKGROUND

The area footprint of stormwater control measures (SCMs) is considered to be a drawback, especially in dense urban environments, and interviews with water professionals in Sweden have shown that the absence of available land is one of the key reasons they are doubtful when it comes to the integration of SCMs in dense city infrastructure (Cettner *et al.*, 2014). Many SCMs such as stormwater ponds rely on sedimentation of particles (Fletcher *et al.*, 2015). These systems are thus often inefficient in treating dissolved pollutants found in stormwater runoff, for example dissolved metals, which are considered to be the most bioavailable metal fraction (Luan and Vadas, 2015). Systems including filtration processes can provide such treatment. However, SCMs based on filtration are known to be prone to clogging (Lucke and Nichols, 2015) and require considerable maintenance.

Compact underground sedimentation vaults are SCMs that offer a viable and area-efficient option for stormwater treatment. Thus, these systems are used to retrofit existing stormwater sewers with no treatment options. There is, however, a lack of scientific publications on their efficiency in treating stormwater pollutants, when compared to e.g. stormwater ponds, wetlands or biofilters. A recent study has shown an insufficient performance of a similar compact sedimentation system even for sediment and particulate bound pollutants (Lange *et al.* 2022).

EcoVault (ESI, 2018) is a precast concrete stormwater treatment system that is investigated in this study. The facility includes two sedimentation chambers and a filter cassette containing zeolite as filter material. The advantage is the size since the area of each facility accounts for approximately 25 m². The potential downside to these facilities is that they are a precast structure, thus it is difficult to adapt the facility size to the specific size and type of the catchment. The objective of this study is to evaluate the treatment performance of the EcoVault systems and discuss the challenges of retrofitting stormwater network.

2 METHODS

Two compact facilities have been chosen to be retrofitted in the existing stormwater sewer network. The network drains stormwater from two urban catchments in Sundsvall, Sweden, with respective areas of 16 and 7.2 ha. The facilities are identical in size, except for the size of the inflow and outflow pipe, which measure 1200 mm and 1400 mm, respectively. In this abstract, results from the sampling of the 16 ha-catchment facility are presented. In order to investigate the effectiveness of the treatment function of the EcoVault facility, a sampling campaign using automatic samplers to produce time-proportional composite samples of each rain event was conducted. Samples are taken in the influent pipe upstream of the treatment facility, in the facility before the filter element and in the effluent pipe (Figure 1, left). In order to monitor the filter overflow events, two level sensors were installed, just upstream and downstream of the filter element. In total, 6 storm events were sampled between May and November

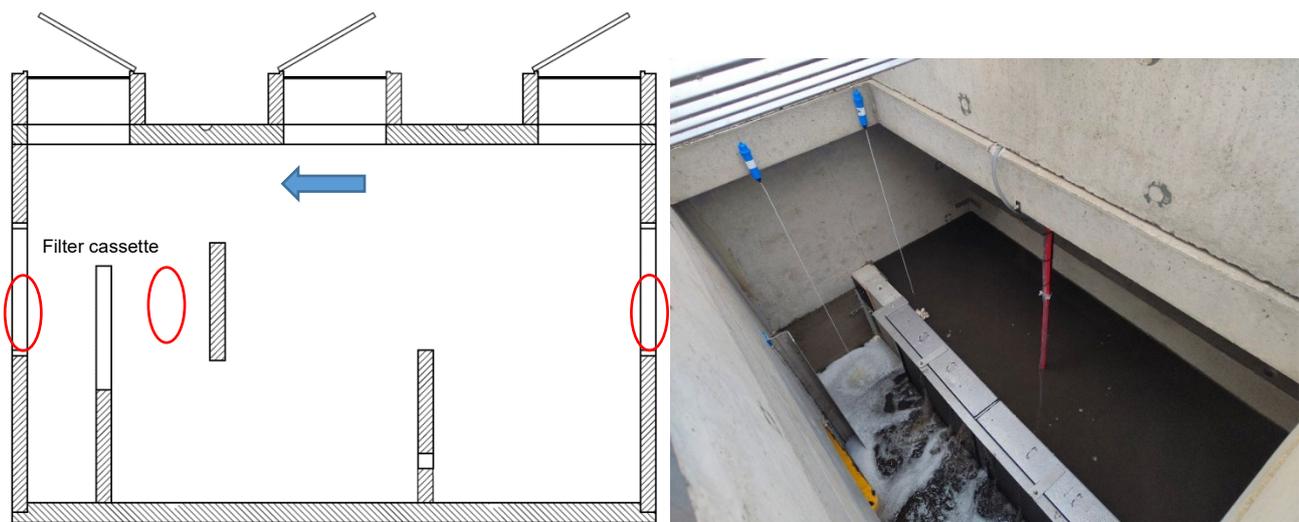


Figure 1: left - Sketch of the EcoVault treatment facility with influent, before filter and effluent sampling points (marked with red ovals); right – photo of the outlet part of the EcoVault facility during a rain event with level sensors visible.

2022. The flow to the facility was measured upstream by an ISCO 2150 area velocity flow sensor.

Samples were analysed for total suspended solids (TSS), pH, conductivity, turbidity, total and dissolved metals (Cu, Zn, Cd, Ni, Cr, Pb), (total N, NO₃⁻ NO₂⁻ NH₄⁺, total P, phosphates), and organic pollutants.

3 RESULTS AND DISCUSSION

Total and dissolved concentrations of Cu and Zn are presented in figure 2. The mean removal of total Cu was relatively low, ranging from 6% to 42% with average treatment of 25% in the samples taken after the sedimentation step. Similar levels were observed in the samples taken after the filtration step (11% to 39% with average treatment of 24%), over the 6 analysed rain events.

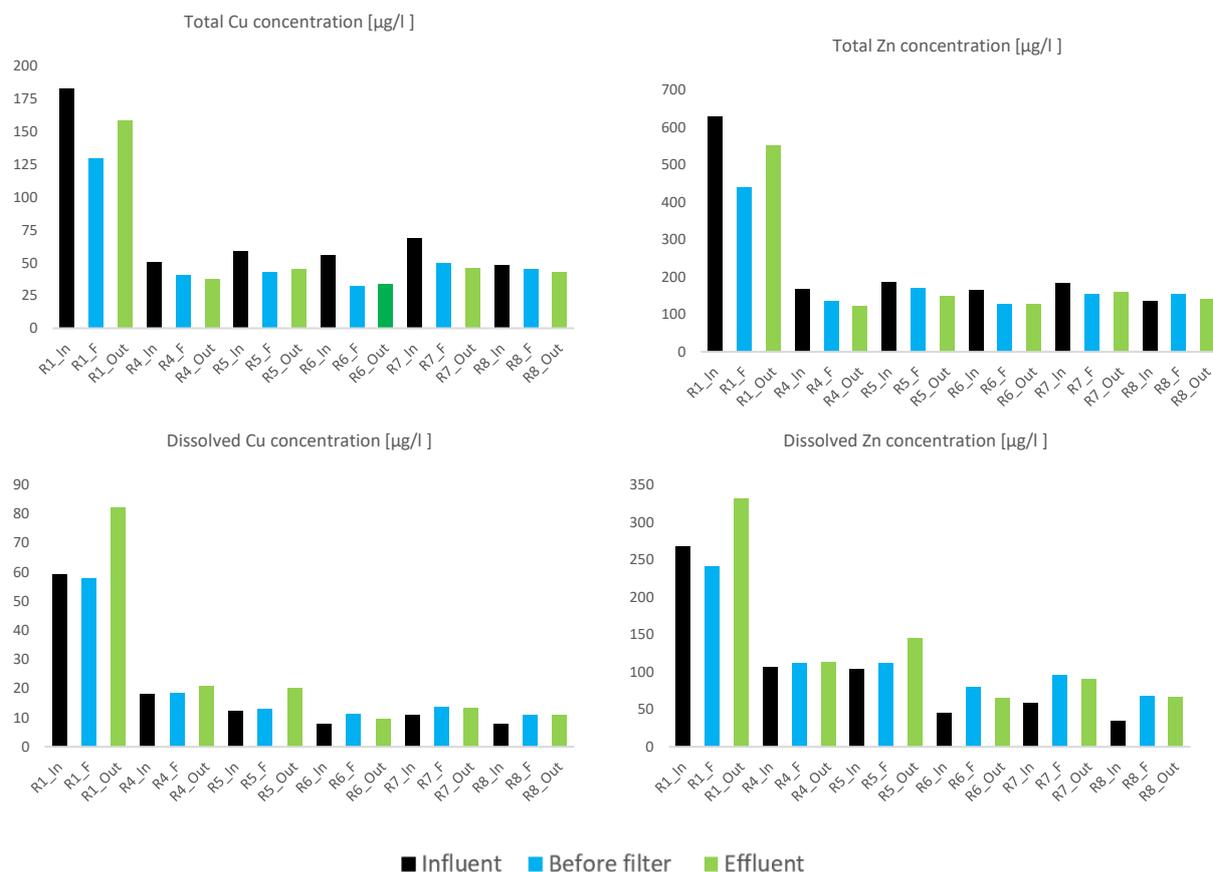


Figure 2: Total and dissolved concentration of Cu and Zn in the influent, before filter and effluent samples over the 6 rain events

Similarly, removal of total Zn was in the range of -14% to 30% (mean: 14%) for before filter samples and -5% to 27% (mean: 15%) after the filter in the effluent samples. Visual observation during the rain events indicated that the filters were clogged already from the first event and that even during the baseflow most of the water was flowing over the cassette holding the filter material instead of passing through it. A photo of a rain event where this was visible is presented in figure 3. This could explain the lack of treatment of dissolved metals, where there was an increase of dissolved concentrations of Cu by 18% and 33% in before filter and effluent samples, respectively, and increase of Zn by 40% and 44%, respectively.



Figure 3: Photo of the outlet part of the facility during a rain event with water flowing over the filter cassette

The results for the TSS are presented in Figure 4. Excluding rain event 4, where unusually low concentration of solids were detected both in the inflow and outflow, treatment for TSS ranged from 50% to 70% with the average treatment of 58% for the samples before filter. Similar levels of treatment were noticed in the outlet samples, where treatment ranged from 33% to 67%, with average treatment of 50%.

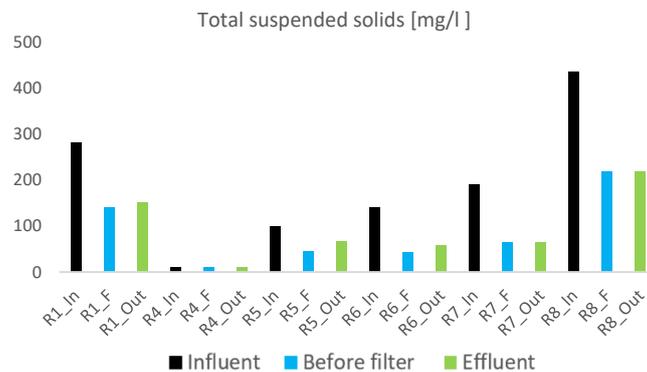


Figure 4: Total suspended solids in influent, before filter and effluent samples

4 CONCLUSIONS AND FUTURE WORK

These results indicate that the EcoVault facility was able to reduce the TSS concentration in the effluent samples by 50% over the examined 6 rain events. Treatment of total Cu and Zn was relatively low, and there was no treatment of dissolved Cu and Zn, likely due to the filter clogging which occurred despite the sedimentation step. We will continue to monitor the facility presented in this study and compare the effectiveness to the other facility described in the method section. The area difference between the two catchments will allow for the evaluation of the performance of the two systems based on the different loading rate. Thus, more results can be presented at the Novatech-conference.

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